Ferromagnetic Phase Transition in a Heisenberg Fluid:
Monte Carlo Simulation and Fisher Corrections to Scaling

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We report the results of Monte Carlo (MC) simulations near the ferromagnetic order-disorder phase transition in a Heisenberg model ferrofluid [1]. The MC simulations were carried out using a biasing scheme [2] for sampling orientational degrees of freedom. The interparticle potentials were chosen as a truncated Yukawa-type potential for spin interactions and a soft sphere potential for liquid subsystem. Varying the temperature at a fixed density ($n = 0.6$) we locate the transition by means of a finite-size scaling (FSS) analysis [3]. A wide range of numbers of particles N, considered in our study (from 125 to 16384), allows us to obtain reliable estimates for the critical exponents. Being in agreement with previous studies [4], our results differ from those for the lattice Heisenberg model. This difference becomes smaller when a number of particles included in the FSS analysis increases. However, even for the largest N deviations from lattice results are observed, although the lattice exponents are expected.

In order to solve this puzzle, one has to observe that a Heisenberg ferrofluid is a system in which a thermodynamic constraint has influence on the critical behavior [5]. Within the Heisenberg universality class constraints lead to Fisher corrections to scaling, which modify the asymptotic form of the universal finite-size scaling functions. These corrections, which must not be confused with Wegner corrections to scaling, are governed by the specific heat exponent $\bullet$. Since the exponent $\bullet$ is smaller than the Wegner exponent, these corrections decay more slowly then those and have to be taken into account in the scaling analysis. This has been done in our analysis of the numerical data, and indeed the critical exponents of the lattice Heisenberg model were reproduced.

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